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How spiral computed tomography can be helpful in the evaluation of urinary stones composition?

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ABSTRACT

Introduction: Knowing the composition of a urinary calculus is frequently a key factor in determining its most appropriate management. Helical computed tomography (CT) can provide helpful information on stone size and stone composition.
Objectives: We sought to determine the urinary stone composition by CT characteristics.
Materials and Methods: Since March 2008 till August 2009, 120 renal stones were obtained from patients who had undergone pyelolithotomy or nephrolithotomy at the Imam-Ali hospital, Zahedan, Iran. Stones with the largest diameter more than or equal to 5 mm were studied. Each calculus was placed inside the chicken lean meat. The radiologist was unaware of the exact chemical composition of the stones. We used independent sample *t* test for comparison of the absolute Hounsfield unit (HU) values of the different types of calculi.
Results: Of total 120 participated patients, 67 (55.8%) were male and 53 of them (44.2%) were female. The mean age of cases was 35.8 ± 12.4 years. According to HU in CT scan and final confirmation with chemical analysis, the calculi were classified into several groups. Of 120 stones, 112 were chemically pure and 8 were mixed. There were 59 calcium oxalate, 27 calcium phosphate, 17 uric acid, 5 struvite, 4 cysteine and 8 mixed stones with variable ratios. In the analysis of the stones, overall difference between densities of the stones was statistically significant ($P < 0.001$).
Conclusion: According to the result of our study, we concluded that the use of non-contrast CT can be helpful in the prediction of urinary stone composition

Implication for health policy/practice/research/medical education:
Mean density of the urinary stones has significant differences. Stone densitometry can be used to differentiate stones from each other. Generally we can state that the use of non-contrast CT and its HU densitometry can be helpful in the prediction of urinary stone composition and it may improve prevention, diagnosis and treatment of urinary stones.

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Original

Introduction

Urinary calculi are a common clinical disorder affecting up to 5% of the general population (1). In both sexes, the prevalence of renal stone disease has been rising, being estimated that about 5% of American women and 12% of men will finally develop a kidney stone during rest of their lifetime (2). Nevertheless, in certain areas of the world, the lifetime risk appears to be even higher as in the Middle East (3). Renal stone disease in children has been heightened awareness (4). Recurrence rates of 50% after 10 years and 75% after 20 years have been reported (5,6). Knowing the composition of a urinary calculus

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is frequently a key factor in determining its most appropriate management. Urine pH, urinary crystals, plain radiography, prior stone history, and the presence of urea-splitting organisms are tools currently used to determination of the stone composition (7).

For stone size and stone composition, helical computed tomography (CT) can provide helpful information. Helical CT can reveal stone size more accurately than standard radiography and nephrotomography (8). Several in vitro studies have suggested that spiral CT can extend these tools for determination differences in radio-density among different urinary stones (9-12).

Bellin et al (12) reported prediction of stone composition with 64%-81% accuracy, whereas Zarse et al (13) demonstrated that high resolution spiral CT yields unique CT numbers for common types of stones if proper window settings are used to localize homogeneous regions within the stones.

Objectives

We sought to determine whether the composition of a urinary stone could be predicted by CT characteristics.

Materials and Methods

Since March 2008 till August 2009, 120 renal stones were obtained from patients who had undergone nephrolithotomy or pyelolithotomy at the Imam Ali hospital, Zahedan, Iran. Stones with the largest diameter more than or equal to 5 mm were studied. Each calculus was placed inside the chicken lean meat. The radiologist was unaware of the exact chemical composition of the stones.

The calculi were scanned with a G force (Tsx-021) dual detector using 3 mm thickness scanning at 120 kV. The mill-amperes were kept constant at 240. Three different 1 pixel region of interest Hounsfield unit (HU) measurements were obtained from each stone (one central and two at the periphery). The average of the 3-pixel HU represents the absolute HU for the pure stone. For this report, the average fraction of the outer and inner composition was determined the overall stone composition.

After scanning, all stones were analyzed by the Pastor biomedical laboratory in Zahedan using crystallography, infrared spectrophotometry and polarization microscopy which generated the percentages of the predominant and secondary components. For pure stones one chemical component comprising more than 70% of the whole were defined.

Ethical issues

1) The research followed the tenets of the Declaration of Helsinki; 2) informed consent was obtained; and 3) This study was approved by the Ethics Committee of Zahedan University of Medical Sciences.

Statistical analysis

Statistical analysis was performed by SPSS software (version 17) and results were presented by using chi-square test. For comparison of the absolute HU in CT scan and values of the different types of calculi, independent sample Student's *t* test was applied. Results were considered significant when $P<0.05$.

Results

Of total 120 patients participated, 67 patients (55.8%) were male and 53 of them (44.2%) were female. Gender frequency distribution of urinary stone composition presented in Figures 1 and 2.

According to HU in CT scan and final confirmation with chemical analysis, the calculi were classified into several groups. Of the 120 stones, 112 were chemically pure and 8 were mixed. There were 59 calcium oxalate, 27 calcium phosphate, 17 uric acid, 5 struvite, 4 cystine and 8 mixed stones with variable ratios. In the analysis of stones, the overall difference between densities of the stones was statistically significant ($P=0.001$; Table 1).

Discussion

Our results showed that the mean density of the stones has significant differences so maybe stone densitometry can be used to differentiate stones from each other. Uric acid stones had a lower density than other types. Uric acid stones can be often indistinguishable from the other stones. In the study of Deveci and colleagues (14), in vitro environment 107 stones were scanned and difference

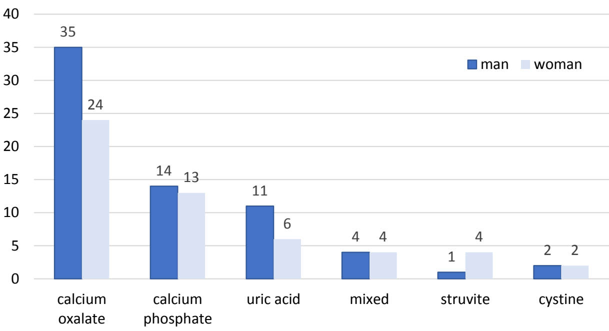

Figure 1. Frequency distribution of urinary stone composition base on gender.

	uric acid	calcium oxalate	calcium phosphate	cystine	Struvite
mean	680	1815	1748	1123	997
minimum	544	1303	1382	1062	401
▲ maximum	816	2327	2114	1184	1593

Figure 2. HU (Hounsfield unit) density and stone composition.

Table 1. Measured CT characteristics of stone[a]

Stone type	No.	Absolute CT value ± SD (HU)
Uric acid	17	680±136
Calcium oxalate	59	1815±512
Calcium phosphate	27	1748±366
Cystine	4	1123±61
Struvite	5	997±596

[a] $P < 0.0001$

between densities of stones was statistically significant ($P<0.001$). Noticeably, they used 1 mm cutting in the scanning which is not useful for assessment of flank pain while in our study 3 mm cutting was used that is consistent with protocol of CT scan for renal stone. Likewise, we used lean meat that is similar to kidney tissue. Hillman and colleagues (15) scanned 36 stones in water environment and could distinguish uric acid stones from struvite and oxalate calcium.

In most studies, uric acid stones are indistinguishable easily from other stone (9-11). Mostafavi and colleagues (11) differentiated easily chemical composition of calcium oxalate, struvite and uric acid stones which was similar to our study. In addition, we assessed cystine and calcium phosphate stones.

Saw and colleagues (16) despite the conclusions based on the thickness of 1 mm, have proposed that scan cutting must be wider than 1 mm for assessment of urinary tract for stones. They also showed that thickness of cutting effects on analysis of stone density. Thus, we selected 3 mm cutting as it is more practical. Demirel et al (17) differentiated uric acid, calcium oxalate and struvite stones based on mean HU densities. In their study, uric acid had lowest density and calcium oxalate had highest density but cystine and phosphate calcium were not assessed.

In our study, stone density had not significantly different between men and women ($P=0.32$). Hence, the patient's gender alone has no effect on the density of stones although this hypothesis requires more detailed studies. Struvite stone has been observed in women more than men that is consistent with other studies (1-3). Urinary tract stone disease is common in the Western world. Non-enhanced CT is the method of choice for stone diagnosis. However, it has a limited role for stone type predicting. Stone composition is currently determined by postoperative assessment of stone fragments. A noninvasive tool for determination of stone composition would improve patient management (18-20).

Conclusion

Generally, we can state that the use of non-contrast CT can be helpful in the prediction of urinary stone composition.

Limitations of the study

We did not follow patients for their future urinary stone formation and metabolic evaluation.

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Authors' contribution

SHG and ZR conceived the study and contributed reagents and tools. SA and MRC performed the experiments. BN and ERM analyzed the data and drafted the final manuscript; all authors read, revised, and approved the final manuscript.

Conflicts of interest

There were no points of conflicts.

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